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Mr. Fletcher

TRANSISTOR SOUND LEVEL METER

10S/CA 761 TYPE 1400E (10S/CA
TTOS OFFICE

INSTRUCTION BOOK

DAWE INSTRUMENTS LIMITED

Ministry of Aviation
Tels. Engineering Records Section,
19-29 Woburn Place, W.C.1
6 MAR 1962

OPERATING INSTRUCTIONS
FOR

TRANSISTOR SOUND LEVEL METER

105/CA761 TYPE 1400E (105/CA761)
TTOS OFFICE

Sn. 2681

CALIBRATED WITH TYPE 1400E/M MICROPHONE
SERIAL No. 3291 MICROPHONE SENSITIVITY
minus 62.5 dB re IV/dyn/cm²

DAWE INSTRUMENTS LIMITED,
~~HARLEQUIN AVENUE~~ ~~WESTERN AV~~,
STET. ~~GREAT WEST ROAD~~ ~~LONDON, W.3.~~
~~BRENTFORD, MIDDLESEX~~
~~ISLeworth 7331-4~~
~~ACORN 6451/4.~~

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CONTENTS

Section		Page
1.	SCHEDULE OF PARTS	4
2.	ACCESSORIES	4
3.	INTRODUCTION	5
4.	DESCRIPTION	9
5.	INSTALLATION	11
6.	OPERATION	13
7.	MAINTENANCE	22
8.	SPECIFICATION	24
9.	GUARANTEE	25
10.	SERVICING PROCEDURE	25
Fig. 1.	RELATIVE LEVELS OF TYPICAL NOISES	30
Fig. 2.	EQUAL LOUDNESS CONTOURS	31
Fig. 3.	RELATION BETWEEN LOUDNESS AND LOUDNESS LEVEL	32
Fig. 4.	I.E.C. OVERALL FREQUENCY RESPONSE	33
Fig. 5.	CORRECTION FOR BACKGROUND NOISE	34
Fig. 6.	LOCATION OF MAJOR COMPONENTS	35
Fig. 7.	CIRCUIT OF POWER UNIT TYPE 1400E/PU	36
Fig. 8.	COMPLETE CIRCUIT DIAGRAM	37

1. SCHEDULE OF PARTS

The complete equipment comprises the following parts:—

1.1. One instrument Type 1400E complete with microphone Type 1400E/M and fitted with the following transistors and diodes wired in circuit:—

Thirteen—OC71 (Mullard) Transistors.

One —XA102 (Edison-Swan) Transistor.

Three —ZW2 (Ferranti) Diodes.

1.2. Three—9 V Batteries Type PP4 (Ever-Ready) or equivalent.

1.3. Four —Screened Jack Plugs Igranic Type P50 (Modified).

1.4. One —Leather " ever-ready " carrying case.

1.5. One —Instruction Book IB. 1400E.

2. ACCESSORIES

2.1. Microphone extension leads are available as follows:—

(*a*) Type 1400E/1 12 ft. 6 in. long.

(*b*) Type 1400E/2 25 ft. long.

2.2. A separate Mains Power Unit Type 1400E/PU is available to operate the Transistor Sound Level Meter Type 1400E from 100–125V or 200–250 V, 50–60 c/s mains supplies instead of from the internal batteries. The Type 1400E/PU is supplied with a 6 ft. mains lead.

2.3. High Level Microphone Type 1400E/4 is available for sound level measurements up to 200 dB.

3. INTRODUCTION

3.1. General

In recent years the measurement of sound levels has become a matter of considerable importance. The reduction of noise has beneficial effects on the health of individuals and on their efficiency, and the quantitative evaluation of noise is therefore of growing interest not only in factories and offices but to public authorities, transport organisations, etc. In the extreme there is the serious risk of permanent hearing loss by prolonged exposure to high level sounds.

When using a sound level meter such as the Type 1400E it is important to recognise the standard definitions and also some of the difficulties associated with acoustic measurements.

The following paragraphs are intended to outline some of the relevant factors.

3.2. Sound Waves

Sound waves cause variations in the normal atmospheric pressure. This variation in pressure is measured in dynes per square centimetre, one dyne per square centimetre being one-millionth of the normal static pressure. The range of sound pressure to which the human ear responds is approximately 0·0002 to 200 dynes per square centimetre and for convenience a logarithmic scale of decibels is used for sound level measurements. The sound pressure level is defined as the ratio in decibels of the magnitude of the sound pressure to the standard reference sound pressure of 0·0002 dyne per square centimetre. This reference level is in the region of the threshold of audibility for a 1,000 c/s pure tone. Fig. 1 gives the relative sound pressure in dynes per square centimetre and the sound pressure level in decibels for typical sounds.

3.3. Normal Hearing Characteristics

Loudness is an observer's auditory impression of the strength of a sound. The loudness of a sound is primarily related to the sound pressure, although, due to the complexity of the response of the human ear, other factors are also involved. The unit of loudness level is the *phon*, which is defined in British Standard B.S. 661 on the basis of a subjective comparison

between the sound being considered and a 1,000 c/s reference tone. The loudness level of the sound in phons is numerically equal to the sound pressure level of the 1,000 c/s reference tone which is judged as the average of the observations of a group of observers to be equally loud.

The ear is not equally sensitive to all frequencies and Fig. 2 shows the sound pressure level in decibels of pure tones at various frequencies required to produce equal sensations of loudness in phons, taking the average of a number of observers. For a group of observers the majority will normally agree within 6 phons, although individual estimates may differ by 10 phons or more. The curves of Fig. 2 are taken from the results of the recent work carried out at the National Physical Laboratory by Robinson and Dadson (" A re-determination of the equal-loudness relations for pure tones," by D. W. Robinson and R. S. Dadson, *British Journal of Applied Physics*, May, 1956, pp. 166–181), and are reproduced by permission of the Director of the Laboratory. These curves differ to some extent from those obtained earlier by Fletcher and Munson (1933) and by Churcher and King (1937), and are likely to form the basis of revised national and international standards in the near future.

It will be noted that no 0 phon curve is given. This is because the threshold of hearing at 1,000 c/s has been found to be about 4 dB above the standard reference level (0 dB=0·0002 dyn/cm^2), so that the lowest curve given is that for the minimum audible field.

The phon scale relates the sensitivity of the ear at various frequencies to that at 1,000 c/s but does not give a direct indication of the change in level necessary to, say, double the loudness of a sound. For this purpose the *sone* scale of loudness has been devised. The reference point of this scale is taken arbitrarily as a loudness of 1 sone for a loudness level of 40 phons. Then a sound which is n times as loud as the reference has a loudness of n sones. It has been found experimentally that, for practical purposes, doubling the loudness corresponds to an increase of loudness level of 10 phons. Similarly, a reduction in loudness level of 10 phons halves the loudness. This relationship, which has been standardised in Great Britain

(B.S. 3045: 1958) and is in course of international standardisation, between the loudness in sones and the loudness level in phons is shown in Fig. 3.

It must be emphasised that, due to the complexity of the hearing mechanism, no universal relationship between the subjective loudness and the physical sound pressure has yet been evolved to cover all types of sound. It will also be appreciated that there is often no simple connection between the sound pressure and the "annoyance" value of a sound. No instrument can distinguish between a "pleasant sound" and an "unpleasant noise."

3.4. The Sound Level Meter

Except under carefully controlled laboratory conditions it is impossible to achieve the basic requirements for a subjective measurement of loudness. However, objective methods of measurement have been standardised in a number of countries to provide a simple consistent basis for practical measurements. The Type 1400E meets the proposed International Electrotechnical Commission (I.E.C.) specification for sound level meters. This is based on the current American Standards Association Specification Z24.3–1944 and the German Specification DIN5045.

The *sound level* in decibels (dB) is defined by:

$$20 \log_{10} \frac{pn}{po}$$

Where *pn* is the r.m.s. sound pressure due to the noise being measured weighted in accordance with certain frequency characteristics detailed in these specifications and *po* is the reference pressure of 0·0002 dyn/cm^2.

The Type 1400E is designed for the direct reading of sound level over the range of 24 dB to 140 dB above the reference level of 0·0002 dyn/cm^2 at 1,000 c/s. It supplements the more accurate Objective Noise Meter Type 1405 and the simpler Sound Level Indicator Type 1408.

Three standard weighting networks, A, B and C, to the proposed I.E.C. requirements are incorporated (see Fig. 4), corresponding approximately to the 40, 70 and 100 phon equal-loudness

contours. The sound level readings in decibels correspond quite closely to the loudness level in phons for single tones and provide a standard of comparison for steady complex sounds.

Some precautions and limitations regarding the application of sound level meters are given in British Standard B.S. 1479: 1948, " The Use of Sound Level Meters."

A useful guide to methods of sound level measurement and analysis is given in the National Physical Laboratory Notes on Applied Science No. 10, " Noise Measurement Techniques " (published by H.M. Stationery Office). Further information and recommendations are given in " American Standard Test Code for Apparatus Noise Measurement," Z24.7–1950, which can be obtained through the British Standards Institution or direct from the American Standards Association.

For an extensive treatise on the subject, reference should be made to " Handbook of Noise Control," edited by C. M. Harris (published by McGraw-Hill).

4. DESCRIPTION

4.1. Applications

The determination and control of airborne noise is a vital problem at the present time. It is now generally appreciated that high level noise is detrimental to the normal health and efficiency of the individual and frequently indicates a fault in the manufacture or design of a product.

The sound level meter provides the essential basic equipment for such investigations, since it measures, on an internationally standardised decibel scale, the value of the alternating pressure waves of the air which are caused by the sound. The Transistor Sound Level Meter Type 1400E has been expressly developed to meet the need for an accurate, reliable instrument for all normal sound level measurements. The latest circuit techniques are used to make possible an extremely compact and portable design which can be conveniently carried and quickly operated in the field.

Typical of the many applications are aircraft and motor vehicle engine noise analysis, noise surveys in concert halls, schools and studios, factory noise tests, acoustic testing of radio and television receivers, the setting up of public address systems, and noise analysis in respect of passenger comfort in ships, cars and aeroplanes.

4.2. Design

This unique design is the first completely transistorised sound level meter commercially available in the world. It conforms to the proposed International Electrotechnical Commission (I.E.C.) specification for sound level meters.

The Type 1400E provides a direct reading of sound level over the range 24 dB to 140 dB. The use of transistors not only considerably reduces size and weight but also virtually eliminates circuit microphony. By the use of advanced techniques the stability of the calibration is superior to that of the thermionic valve equipment, which it replaces, over a wide temperature range.

The instrument consists of a crystal microphone, an impedance matching circuit, a high gain amplifier, weighting networks and an indicating meter. The complete circuit is given in Fig. 8.

The crystal microphone feeds into a specially developed high

impedance input circuit (VT1 to VT3) protected by British Patent Application 16981/59. This is followed by a highly stabilised amplifier consisting of three groups of three transistors (VT4 to VT11). This arrangement has very stable impedance levels between each group ensuring attenuator and weighting networks accuracy. Two further transistors (VT12 and VT13) are used to give a monitor position and drive a special meter rectifier circuit which approximates to a true r.m.s. indication. ("A true R.M.S. instrument," *Brüel and Kjaer Technical Review*, July, 1958.) Throughout the amplifier, transistors are employed in the grounded base or grounded collector configuration. This arrangement has a very high degree of stability, being negligibly affected by normal temperature and battery voltage variations.

The three weighting networks A, B and C to the I.E.C. requirements are incorporated. Two attenuators are provided, one at the input and the other after the second amplifier stage. Both are operated by a single control and give a sensitivity coverage from 24 to 140 dB in 11 steps of 10 dB.

The indicating meter is calibrated from −6 dB to +10 dB. The normal response of the meter is very rapid to simulate that of the human ear and meets the "Fast" speed requirements of the I.E.C. Specification. The meter may be electrically damped to give an average indication for fluctuating sounds (I.E.C. "Slow" response).

An output jack is provided to enable a low distortion, low noise signal to be fed to the Type 1401 A.F. Analyser or Type 1410 Octave Band Analyser for detailed analysis of the component frequencies of the sound. Provision is made for the insertion of 600 Ω filters between the high impedance input circuit and the first stage of the amplifier.

An omni-directional Rochelle-salt crystal microphone is employed. The microphone folds into a recess in the end of the case and automatically operates the battery switch when it is raised. The low current consumption of the instrument permits the use of compact inexpensive batteries which give a typical operational life of 60 hours.

The complete unit, including microphone and batteries, is housed in a very compact and attractive cabinet easily held in one hand. A leather "ever-ready" carrying case is supplied and a mains operated power unit is available.

5. INSTALLATION

Read the label attached to the instrument and note the information given in respect of power supply.

5.1. Carrying Case

The Transistor Sound Level Meter is supplied with an " ever-ready " leather carrying case. To gain access to the instrument unclip the two pairs of press studs on the carrying case. The cover can be clipped on the back of the carrying case for convenience in operation by means of the two press studs at the rear of the case and the two studs on the lower front.

To remove the carrying case completely, unscrew the tripod mounting bush at the bottom and unclip the cross strap above the meter.

5.2. Battery Operation

Remove the leather carrying case completely (see Section 5.1.).

Before attempting to insert the batteries make sure that the microphone arm is folded into the recess in the top of the case, thus switching off the power supply.

The batteries (three Type PP4 Ever-Ready or equivalent) are normally packed separately. They can be fitted when the battery compartment cover in the rear panel has been removed by turning each Dzus fastener one-quarter of a turn anti-clockwise. The batteries are clipped to the panel thus exposed and inserted into the instrument. The panel and batteries are then retained in the instrument by turning the Dzus fasteners one-quarter of a turn clockwise.

The battery panel fixings are offset to prevent the batteries being connected with incorrect polarity. For this reason it is most important that the battery insertion be carried out in the manner described. INCORRECT POLARITY OF THE BATTERIES CAN PERMANENTLY DAMAGE THE INSTRUMENT.

5.3. Mains Power Unit Type 1400E/PU

A separate power unit is available to operate the Transistor Sound Level Meter from a 100–125 V or 200 250 V, 50–60 c/s mains supply.

The Type 1400E/PU is normally supplied connected for operation from 200–250 V mains. To operate the power unit from 100–125 V mains the wiring to the mains transformer must be changed as follows. Remove the screws holding the four rubber feet and then the lower end cap. The wrapper can then be taken off, leaving the component panel attached to the upper end cap. Remove the links between the white and yellow-pins of the mains transformer. Link between the black and yellow pins, also link between the white and blue pins, using insulated wire.

The Mains Power Unit is connected to the Transistor Sound Level Meter as follows:—

First completely remove the leather carrying case and make sure that the instrument is switched off (microphone arm folded away).

Remove the batteries complete with fixing panel and in their place insert the connector supplied with the Power Unit Type 1400E/PU. The Dzus fasteners are offset so that the connection cannot be made with incorrect polarity. The 1400E/PU is connected to the mains supply by means of the three-pin socket and lead supplied.

Red	— Mains (Line)
Black	— Mains (Neutral)
Other Colour	— Earth

As a precaution to ensure that the magnetic field of the mains transformer does not induce hum into the high gain amplifier circuit, the Power Unit should be placed at the full length of the connecting lead from the Transistor Sound Level Meter.

It should be noted that the leather carrying case cannot be used when operating from the mains Power Unit.

6. OPERATION

6.1. Initial Settings

Set the SOUND LEVEL switch to some high value, for example 130 dB, thus preventing any unnecessary overloading of the indicating meter.

Check that all jack plugs are withdrawn unless required for use.

The equipment is switched on automatically by raising the microphone arm to the vertical position. When the Power Unit Type 1400E/PU is used, the MAINS switch on this unit must be set to ON.

6.2. Battery Check

With the equipment switched on set the RESPONSE switch to the BATTERY CHECK " B1," and then the " B2 " position, checking that the meter reading in each case is not less than the red " B " mark on the scale. If the reading is below the " B " mark the batteries must be replaced. (See Section 5.2. and Fig. 6.) Note that both batteries B2 and B3 are checked by the " B2 " setting.

REPLACEMENTS: STORES REF. 5J/CA 111.

6.3. Calibration Check

The calibration is maintained under all normal working conditions, for example battery voltage variations and changes in ambient temperature.

However, it is recommended that an overall acoustic check is carried out at regular intervals or before commencing a series of tests. The Dawe Falling Ball Acoustic Calibrator Type 1417 is recommended for this purpose. This instrument produces a relatively wide band random noise of nominally 90 dB (individually calibrated) at a distance of 10 cm.

The calibrator is completely self-contained, the noise being produced by a large number of small steel balls striking a diaphragm. Details of the calibration procedure are given in the Type 1417 Instruction Book.

6.4. Measuring Sound Level and Sound Pressure Level

With the equipment switched on (microphone arm raised) set the RESPONSE switch to the A, B or C network (see below). Set the meter switch to FAST. Adjust the SOUND LEVEL switch until a deflection is obtained on the indicating meter. The meter reading added to the SOUND LEVEL setting will give the sound level in decibels provided the appropriate setting of the weighting network is selected as follows:—

A ... For sound levels below 55 dB.

B ... For sound levels between 55 dB and 85 dB.

C ... For sound levels above 85 dB.

For some applications, for example vehicle noise measurement, a particular weighting network may be specified irrespective of the level. The reading on the C weighting is also equal to the sound pressure level in decibels relative to 0·0002 dyn/cm^2 over the frequency range 32 c/s to 8 kc/s.

The conditions of measurement should always be recorded and it is frequently advantageous to take readings on all three weighting networks, except on the 30 dB setting of the SOUND LEVEL control on B weighting and the 30 and 40 dB settings on C weighting, where the increased background noise can result in errors (see Section 6.9.). This will avoid any ambiguity in the selection of the proper weighting network and can sometimes be used to give a rough indication of the frequency spectrum of the sounds. For example, if the indication is approximately the same for all weightings, the major component frequencies are at higher frequencies. If an appreciable fall in reading occurs when switching from C to B and B to A, the sound will probably be composed mainly of very low frequency components.

Care is required in the use of a sound level meter in order to obtain accurate indications and the various factors involved are discussed in the following sections.

6.5. Microphone Location

The indication on the meter is for the sound level at the microphone, which is of the omni-directional type and thus responds to sounds arriving from all directions.

The I.E.C. microphone reference direction, at which the overall calibration of the equipment is made, is perpendicular to the microphone diaphragm. Thus if the sound is coming from a single direction the microphone should be " pointed at " the source of sound.

It is convenient to measure the noise produced by such sources as heavy machinery, domestic appliances or office equipment at a standard distance of, say, three feet from the nearest major surface. For some measurements, for example on small electrical appliances, a closer positioning of the order of one foot or six inches may be desirable.

For general use the equipment may be held in front of the body supported by the strap of the leather carrying case around the neck. With " high-pitched " sounds the observer may form an acoustic reflector and thus modify the sound level reaching the microphone. Then if the best possible accuracy is required it is desirable to mount the equipment by means of the $\frac{1}{4}$-in. Whitworth-threaded tripod fixing at a convenient viewing distance from the observer or to connect the microphone to the measuring unit by an extension cable (see Section 6.6.).

6.6. Microphone Extension Cables

The microphone may be detached from the instrument and connected by means of a screened cable for remote indication. The self-capacitance of this cable produces a small loss in sensitivity given by:—

$$20 \log_{10} \quad (1 + \frac{Cc}{Cm}) \text{ dB}$$

Where Cc = capacitance of the cable.
Cm = capacitance of the microphone.

The series capacitance of the microphone is nominally 3,500 pF at 20°C., but varies with temperature.

The standard extension cables available are:—

Type	*Length*	*Nominal Capacitance*	*Correction Factor*
1400E/1	12 ft. 6 in.	350 pF	0·8 dB ± 0·3 dB
1400E/2	25 ft.	700 pF	1·6 dB ± 0·5 dB

The correction factor must be added to the reading of the sound level meter. The tolerance on the correction factor takes into account the variation of microphone capacitance with temperature.

The full type and serial numbers of the Sound Level Meter must be given when ordering extension cables.

6.7. Standing Wave Patterns

When a source of sound is located in the open away from any reflecting objects, the sound pressure level decreases by 6 dB each time the distance from the source is doubled (except over long distances where absorption due to the air must be considered).

However, in an enclosed space, multiple reflections can arise which alter the distribution of the sound pressure. For example, standing waves may be present due to interference between the direct and reflected waves, and thus the resultant will rise and fall as the microphone is moved away from the source. If it is impossible to avoid standing wave effects, the average of adjacent maximum and minimum indications may be taken, or, in the case of a large difference greater than 6 dB, a level of 3 dB below the maximum is more representative.

6.8. Fluctuating Sounds

Sound level measurements should normally be carried out with the METER switch set to the FAST position. In this position the meter response simulates that of the human ear. For sounds which are not constant in level an average reading should be taken if the fluctuation is less than 6 dB.

If the fluctuation is greater than 6 dB, a value 3 dB below the maximum is more representative. Should this fluctuation be rapid and variable it may be advantageous to set the METER switch to SLOW where, due to the long time-constant, an average reading will more easily be obtained.

6.9. Background Noise

The sound level measurement should normally be made under conditions where the background level of noise is negligible, for example when the background level is 10 dB or more below the measured level.

Where the background noise is less than 10 dB below the required level and is reasonably constant, a correction may be employed using the curve shown in Fig. 5.

Due to the use of transistors, the amplifier is unaffected by vibration and high level sound fields so that the usual precautions to avoid errors from microphony are not required. However it should be noted that vibration of the microphone creates a sound field so that the equipment (or the microphone if mounted separately) should be isolated from excessive vibration, particularly at high frequencies.

The circuit noise in the equipment is at least 20 dB and generally 25 dB below full scale deflection on the 30 dB setting of the SOUND LEVEL control for A weighting, 40 dB setting for B weighting and 50 dB setting for C weighting. These levels depend on the setting of the CALIBRATE control and determine the lowest sound level which can be measured for each weighting.

6.10. Wind Shield

When sound measurements are being carried out in the open and in adverse weather conditions, the effects of wind passing across the microphone diaghrapm can give rise to false readings ("wind noise"). This effect can be minimised by a wind shield.

A simple yet effective wind shield can be constructed by covering a thin wire frame, some 6 inches in diameter by 8 inches in height, with a coated nylon fabric (such as employed for showerproof raincoats) or muslin. The advantage of nylon-coated fabric is that it affords some protection of the microphone from rain.

The material should be extended tightly over the open end of the frame so that it can be drawn in and tied around the stem of the microphone. It is usually more convenient to mount the microphone on an extension cable when a wind shield is required. It is essential that the material should not be allowed to flap. In circumstances where a high wind still affects measurements a double wind shield may be necessary.

6.11. Magnetic Fields

When making noise measurements in a strong alternating magnetic field, care must be taken to see that there is no appreciable inductive pick-up by the equipment.

Rotating the instrument may help to reduce hum pick-up. If not, the instrument should be moved away from the field of interference and an extension cable used to the microphone.

6.12. Microphone Limitations

The following limitations of the Rochelle-salt crystal microphone must be observed:—

(*a*) At temperatures below 0°C. (32°F.) the sensitivity of the microphone falls appreciably, although no permanent damage is caused to the microphone. Temperatures in excess of 45°C. (113°F.) will destroy the crystal element.

(*b*) The microphone should not be subjected to sound levels greater than 140 dB.

(*c*) The microphone must not be subjected to humidities greater than 85% R.H. for long periods, particularly at high temperatures, or the crystal may be damaged.

(*d*) The microphone should be handled with reasonable care and not subjected to exceptional mechanical shock.

6.13. Output Connection

An amplified signal is available from the OUTPUT jack for connection to an analyser (see Section 6.14.), tape recorder or oscilloscope. At full scale deflection of the meter the level is approximately 1 V r.m.s. into a load resistance of 20 kΩ. The open-circuit output voltage is approximately 1·5 V and any required value of load resistance can be used with negligible change in the meter calibration due to the internal series resistance of 10 kΩ.

If a permanent record of the sound level is required the Dawe High Speed Level Recorder Type 1406 can be connected to the OUTPUT Jack.

6.14. Sound Analysis

For some applications the single reading of sound level does not provide sufficient information, and a more detailed frequency analysis is required. A particular feature of the Type 1400E is that the wide dynamic range of the amplifiers, and careful location of the attenuators and filter jacks in the circuit, enables spectrum analysis to be carried out using the main amplifier and meter, when a suitable filter is connected between the FILTER IN and FILTER OUT jacks with the jack plugs provided. The dynamic range is such that a signal may be passed through a filter in the presence of a masking signal of up to 40 or 50 dB greater amplitude without overloading any stages in the amplifier.

The external network should be designed to work from a source impedance of 600 Ω, have an impedance level of 600 Ω and feed into the 600 Ω terminating resistance of the FILTER IN jack. Under these conditions the filter insertion loss plus 2 dB must be added to the meter reading in order to obtain the correct sound pressure level in the filter band. The C weighting to provide sound pressure level readings is automatically selected when the FILTER IN and FILTER OUT jacks are used.

Filters such as the Standard Telephones Type 74101A, 74143A Octave Filters, Standard Telephones Type 74202A One Third Octave Filter and Telephone Manufacturing Co. Octave Filter can be used with the appropriate correction factor.

The Dawe Type 1465 Variable Bandwidth Filter is particularly useful for the analysis of sound spectra. It consists of a 600 Ω passive network which can be continuously tuned to obtain high-pass, low-pass or band-pass characteristics at all audio frequencies between 20 c/s and 20 kc/s. It has zero insertion loss in the pass-band except where a narrow band-pass characteristic is used; for example, the insertion loss is nominally 3 dB for an octave band. For details of the operation refer to the Type 1465 Instruction Book.

Initially the SOUND LEVEL control should be set to give a meter reading within the calibrated scale range preferably near full scale deflection with the external filter set to an all-pass position or completely disconnected from the Type 1400E.

When analysing the sound spectrum, the SOUND LEVEL control is adjusted to obtain a meter reading within the calibrated range for each filter band. This will ensure that the amplifier circuits are operated within their linear range. The level in each filter band is then given by the meter and attenuator readings plus 2 dB plus the filter insertion loss.

Alternatively suitable analysers can be connected to the OUTPUT jack. The required weighting network (usually " C ") must then be selected by the RESPONSE switch.

The Dawe Type 1410 Octave Band Analyser can also be used with the Transistor Sound Level Meter. The Type 1410 includes amplifier and meter circuits and is connected to the OUTPUT jack of the Type 1400E equipment. For details of the operation refer to the Type 1410 Instruction Book.

Where a more detailed analysis of the component frequencies is required the Dawe Type 1401 A.F. Analyser or a similar narrow band analyser can be connected to the OUTPUT jack on the Type 1400E equipment. For details of the operation refer to the Type 1401 Instruction Book.

The Dawe Type 1412 Impact Noise Analyser can also be connected to the OUTPUT jack to determine the peak value and decay characteristics of single or repeated impulsive noises. A positive half cycle from the OUTPUT jack corresponds to an increase in the sound pressure. For details of the operation refer to the Type 1412 Instruction Book.

6.15. High Level Microphone Adaptor Type 1400E/4

The Type 1400E/4 Microphone Adaptor extends the range of the Type 1400E Sound Level Meter up to 200 dB above the reference level of 0·0002 dyn/cm^2. In order that the unit may be calibrated for use with an existing Type 1400E instrument, the Microphone Sensitivity data given on the front page of this Instruction Book must be supplied with the order for the Type 1400E/4.

The unit consists of an ammonium-dihydrogen phosphate crystal microphone, manufactured by Massa Laboratories, Inc., U.S.A. A 20-ft. lead connects the microphone to an impedance

matching unit which is inserted in place of the normal microphone. The equipment is particularly suitable for sound level measurement in engine test pens and near jet aircraft. The 20-ft microphone lead enables the Sound Level Meter and the observer to be sited in an area of relatively low sound intensity.

A correction factor of 60 dB must be added to the reading of the Transistor Sound Level Meter. Background noise approximates to 97 dB sound level on C, 85 dB on B and 80 dB on A weighting. To minimise error from this source, the C weighting should not be used on the 30 dB and 40 dB attenuator settings (SOUND LEVEL switch). Similarly the B weighting should not be used on the 30 dB setting.

Specification (Type 1400E/4 used with Type 1400E)

Sound Level Range:	86 dB to 200 dB on A weighting 96 dB to 200 dB on B weighting 106 dB to 200 dB on C weighting Above standard reference level of 0·0002 dyn/cm^2.
Frequency Response:	Approximately normal on A, B and C weightings. Typical low frequency —3 dB point is 50 c/s.
Maximum Operating Temperature:	71°C. (160°F.).
Capacitance:	Microphone and cable approx. 500 pF (padded to approx. 2,500 pF with the impedance matching unit).
Dimensions:	Microphone $2\frac{3}{8}$ in. (61 mm) long. $\frac{5}{8}$ in. (16 mm) diameter. $\frac{3}{4}$ in. (19 mm) mounting rim diameter.

7. MAINTENANCE

7.1. Battery Replacement

For details of battery replacement refer to Sections 6.2. and 5.2.

7.2. Dismantling

After removing the leather carrying case (see Section 5.1.) unscrew the four Philips head 6 BA screws around the top trim of the instrument and the four screws around the bottom end cap. The top trim and bottom end cap can then be removed. To remove the rear cover, two additional screws adjacent to the battery cover must also be unscrewed.

7.3. Calibration

The overall acoustic calibration is set at the factory for the particular microphone supplied. The serial number and sensitivity of the microphone are marked in the microphone recess and also entered on the front page of this Instruction Book.

If a fault is suspected, or a discrepancy of several decibels arises from a check with the Falling Ball Acoustic Calibrator Type 1417 (Section 6.3.), the electrical calibration should be checked as follows:—

With the microphone in the raised position, feed an accurately known signal of 20 mV $\pm 1\%$ at 1 kc s into the INJECT jack (input impedance 100 Ω) and check that on the " C " position of the RESPONSE switch, SOUND LEVEL control at " 90," the meter reading obtained corresponds to the figure given in the table which follows. If necessary remove the chrome 0 BA screw marked CALIBRATE and adjust the preset potentiometer beneath with a small screw-driver until the correct reading is obtained. The microphone must be in a quiet location (sound level 70 dB or lower) for this test.

Microphone Sensitivity (*dB re 1V/dyn/cm² at 1 kc/s*)	*Meter Reading* (*Decibels sound pressure*)
−54	94
−55	95
−56	96
−57	97
−58	98
−59	99
−60	100

If a new microphone is fitted the overall acoustic calibration of the equipment should be checked and if necessary reset by an acoustic standardising laboratory. Alternatively the Type 1417 Falling Ball Acoustic Calibrator may be used (see Section 6.3.) or, if the microphone sensitivity is known, the electrical calibration described can be used.

8. SPECIFICATION

Sound Level Range:	24 dB to 140 dB above the standard sound pressure level of 0·0002 dyn/cm².
Frequency Characteristics:	Three standard weighting curves. (I.E.C. Specification.) A—40 dB equal loudness contour. B—70 dB equal loudness contour. C—Essentially flat: 3 dB points at 32 c/s and 8 kc/s.
Microphone:	Rochelle-salt crystal diaphragm type microphone. Minimum operating temperature 0°C. (32°F.). Maximum operating temperature 45°C. (113°F.). Maximum relative humidity 85%.
Attenuator:	30 dB to 130 dB in eleven steps of 10 dB.
Meter:	Calibration from −6 dB to +10 dB.
Calibration:	The overall acoustic calibration is set for the microphone supplied with the instrument against a reference microphone the sensitivity of which is periodically checked by the National Physical Laboratory.
Output:	Full scale deflection of the meter corresponds to approximately 1 V into a resistive load of 20 kΩ.
External Filters:	Jacks are provided for connecting external filters having an impedance of 600 Ω.
Power Supply:	Three dry cells PP4 Ever-Ready or equivalent, or external mains operated power unit which can be supplied as an accessory.
Mounting:	Extremely compact and portable metal cabinet fitted with $\frac{1}{4}$-in. Whitworth bush for tripod mounting. Leather carrying case supplied.
Dimensions:	$8\frac{1}{4}$ in. × $5\frac{3}{4}$ in. × $3\frac{3}{4}$ in. overall.
Weight:	4 lb approximately.

9. GUARANTEE

Our Products are carefully inspected and submitted to comprehensive tests at our factory before despatch. We therefore give to all purchasers (subject to the terms of payment and all the customer's other obligations being strictly observed) the following guarantee, which excludes and takes the place of any condition or warranty implied by Statute or otherwise.

If within three years from the date of despatch, any defect is discovered in any apparatus in respect of material or workmanship and reasonably within our control, we undertake to make good the defect at our own expense, provided notice is given to us as soon as it is discovered, and that the apparatus is immediately forwarded to our factory, carriage paid and with seals unbroken. Our responsibility is in all cases limited to the cost of making good the defect in the apparatus itself. This guarantee is given to our customers and does not extend to third parties, nor does it apply to defects caused by wear and tear, abnormal conditions of working, accident, misuse or neglect.

In the case of material or components not of our manufacture we are prepared to give the customer the benefit of any guarantee given to us in respect thereof.

10. SERVICING PROCEDURE

Should it become necessary to return this instrument for service at any time, we shall be glad if you will proceed as follows:—

(1) Write giving the type and serial number with the fullest possible details of the fault or of the service required and post to: **Service Department, Dawe Instruments Limited, 7, Spur Road, Isleworth, Middlesex.**

(2) Send the instrument to the above address, **Complete with Accessories and Instruction Book, and pack a copy of the above letter with the Instrument.**

This procedure will facilitate the work of our Service Department and expedite the return of the instrument.

COMPONENTS LIST FOR MAINS POWER UNIT

TYPE 1400E PU

Circ. Ref.	RESISTORS
R1	15 k Ω Morganite S ±10%
R2	2·2 k Ω Morganite S ±10%
R3	10 k Ω Morganite S ±10%
R4	330 Ω Morganite S ±10%

	CAPACITORS
C1	250 μF Hunts MEF35T 25 V
C2	250 μF Hunts MEF35T 25 V
C3	250 μF Hunts MEF35T 25 V
C4	250 μF Hunts MEF35T 25 V

	MISCELLANEOUS
T1	Transformer Fortiphone PP732
W1	Diode Mullard CV448
W2	Diode Mullard CV448
S1	Switch N.S.F. 8373/K8
PL1	Plug D.I. Drg. No. C10466
PL2	Plug Bulgin P73

COMPONENTS LIST FOR TRANSISTOR SOUND LEVEL METER TYPE 1400E

Circ. Ref.		RESISTORS	Tol.
R1	470 k Ω	Welwyn C21	± 5%
R2	1·5 M Ω	Welwyn C22	± 1%
R3	33 k Ω	Welwyn C21	± 5%
R4	68 k Ω	Welwyn C21	± 5%
R5	180 k Ω	Welwyn C22	± 1%
R6	150 k Ω	Welwyn C21	± 5%
R7	10 k Ω	Welwyn C21	± 5%
R8	15 k Ω	Welwyn C21	± 1%
R9	1·5 k Ω	Welwyn C21	± 1%
R10	4·7 k Ω	Welwyn C21	± 5%
R11	100 Ω	Welwyn C21	± 1%
R12	1 k Ω	Welwyn C21	± 5%
R13	560 Ω	Welwyn C21	± 5%
R14	220 Ω	Welwyn C21	± 5%
R15	390 Ω	Welwyn C21	± 5%
R16	4·7 k Ω	Welwyn C21	± 5%
R17	6·8 k Ω	Welwyn C21	± 5%
R18	15 k Ω	Morganite S	10%
R19	15 k Ω	Morganite S	10%
R20	4·7 k Ω	Morganite S	10%
R21	470 Ω	Morganite S	10%
R22	470 Ω	Morganite S	10%
R23	2 k Ω Pot.	Morganite Lin. U	± 20%
R24	4·7 k Ω	Morganite S	± 10%
R25	10 k Ω	Morganite S	± 10%
R26	22 k Ω	Morganite S	± 10%
R27	15 k Ω	Morganite S	± 10%
R28	6·8 k Ω	Morganite S	± 10%
R30	1·35 k Ω	Welwyn C21	± 1%
R32	3·25 k Ω	Welwyn C21	± 1%
R33	13·5 k Ω	Welwyn C21	± 1%
R34	46 k Ω	Welwyn C21	± 1%
R35	148·5 k Ω	Welwyn C22	± 1%
R36	22 k Ω	Morganite S	± 10%
R37	4·7 k Ω	Morganite S	± 10%
R38	15 k Ω	Morganite S	± 10%
R39	6·8 k Ω	Morganite S	± 10%
R40	470 Ω	Morganite S	± 10%
R41	1 k Ω	Morgan te S	± 10%
R42	1·5 k Ω	Morganite S	± 10%
R43	5·6 k Ω	Morganite S	± 10%
R44	2·2 k Ω	Morganite S	± 10%
R45	10 k Ω	Morganite S	± 10%
R46	15 k Ω	Morganite S	± 10%
R47	2·2 — 10 M Ω	Morganite S	10%

Circ. Ref.		RESISTORS	Tol.
R48	4·7 k Ω	Morganite S	± 10%
R49	15 k Ω	Morganite S	± 10%
R50	10 k Ω	Morganite S	± 10%
R51	22 k Ω	Morganite S	± 10%
R52	56 k Ω	Welwyn C21	± 5%
R53	122 k Ω	Welwyn C21	± 5%

		CAPACITORS		Wkg. Volt.
C1	50 μF	Daly	E515–2	12
C2	·05 μF	Hunts	A305	250
C3	50 μF	Daly	E515–2	12
C4	·25 μF ± 10%	Hunts	B501	150
C5	50 μF	Daly	E515–2	12
C6	50 μF	Daly	E515–2	12
C7	50 μF	Daly	E515–2	12
C8	100 μF	Daly	A349–2	12
C9a	1 μF ± 10%	Hunts	B503	150
C96	·25 μF ± 10%	Hunts	B501	150
C10	50 μF	Daly	E515–2	12
C11	50 μF	Daly	E515–2	12
C12	10 μF	Daly	H5 5/2	12
C13	500 μF	T.C.C.	CE 17AE	6
C14	50 μF	Daly	E515–2	12
C15	1 μF ± 20%	Hunts	B503	150
C16	250 μF	Hunts	MEF 35 TYD	25
C17	·005 μF ± 10%	Hunts	B805	150
C18	68 pF Dubilier S635 (or similar)			± 10%
C19	500 pF Dubilier 635 (or similar)			± 20%

VT1	XA102	Ediswan
VT2	OC71	Mullard
VT3	OC71	Mullard
VT4	OC71	Mullard
VT5	OC71	Mullard
VT6	OC71	Mullard
VT7	OC71	Mullard
VT8	OC71	Mullard
VT9	OC71	Mullard
VT10	OC71	Mullard
VT11	OC71	Mullard
VT12	OC71	Mullard
VT13	OC71	Mullard
VT14	OC71	Mullard

MISCELLANEOUS

S1	Switch N.S.F. D.I. Drg. No. C10090
S2	Switch N.S.F. D.I. Drg. No. C10091
S3	Switch Bulgin Type S690
S4	Switch Arcoletric Type T225
J1	Jack Igranic Type P72
J2	Jack Igranic Type P72
J3	Jack Igranic Type P72
J4	Jack Igranic Type P72
B1	Battery Ever-Ready PP4 9 V
B2	Battery Ever-Ready PP4 9 V
B3	Battery Ever-Ready PP4 9 V
W1	Diode Ferranti Type-ZW2
W2	Diode Ferranti Type ZW2
W3	Diode Ferranti Type ZW2
W4	Instrument Rectifier (supplied with M1)
L1	Choke D.I. Drg. No. B10376
M1	Meter Weston S155–1–17 D.I. Drg. No. C7508
MIC.	Microphone D.I. Drg. No. C10077
SK1.	Socket Plessey " Modac " T3261

C3324

Fig. 1 RELATIVE LEVELS OF TYPICAL NOISES

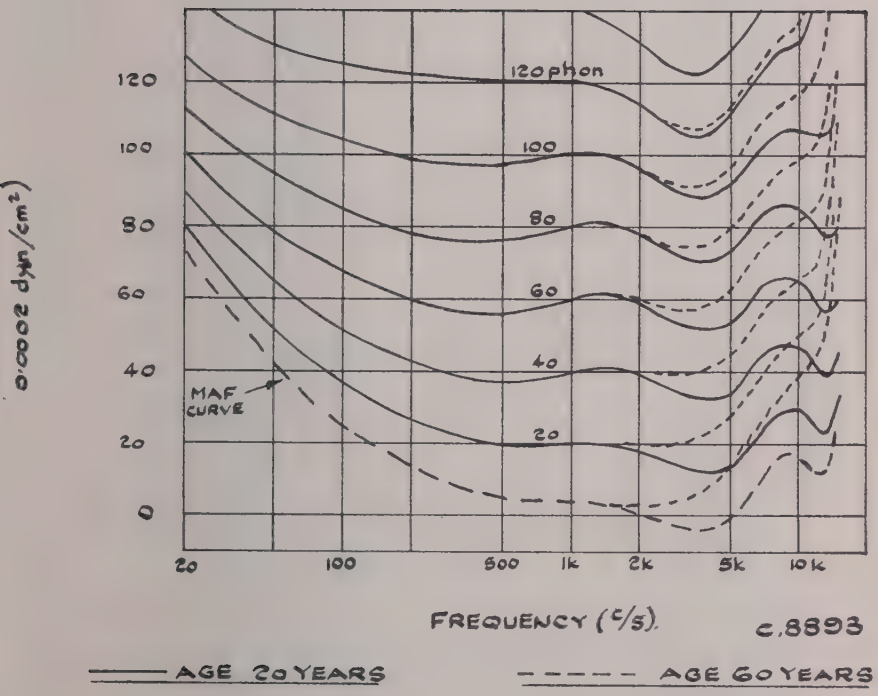


Fig. 2 EQUAL-LOUDNESS CONTOURS FOR PURE TONES
(Robinson and Dadson)

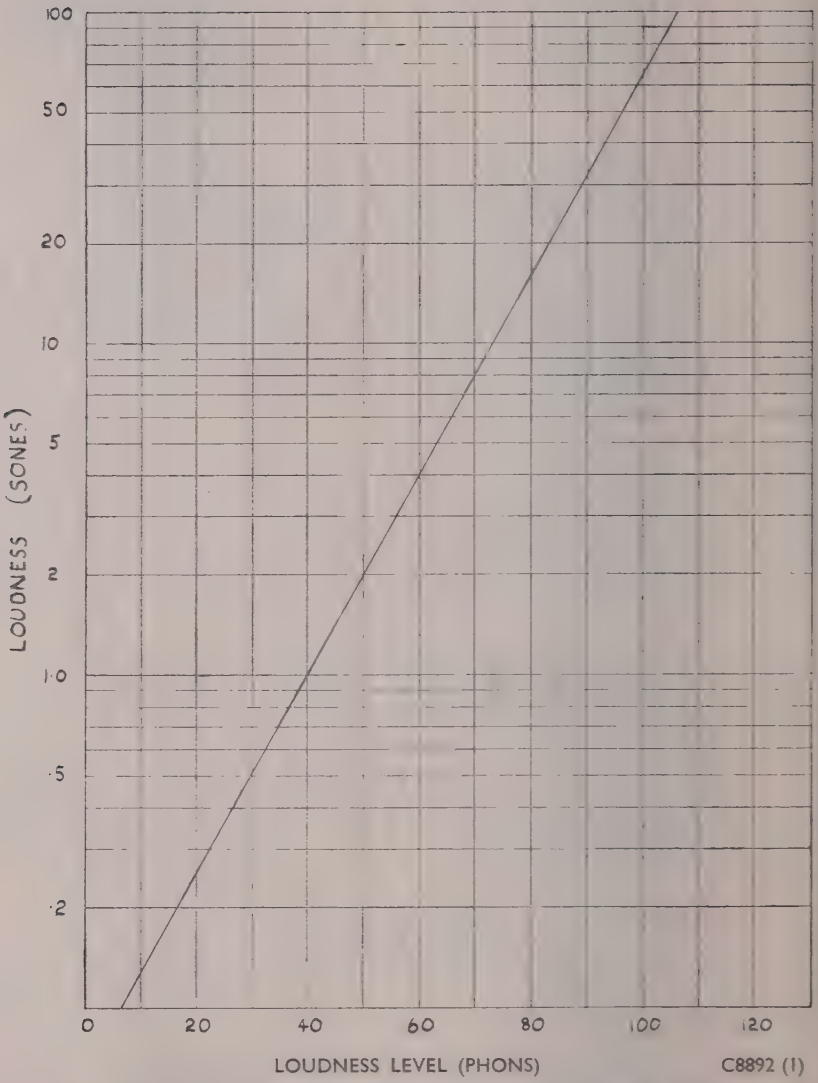
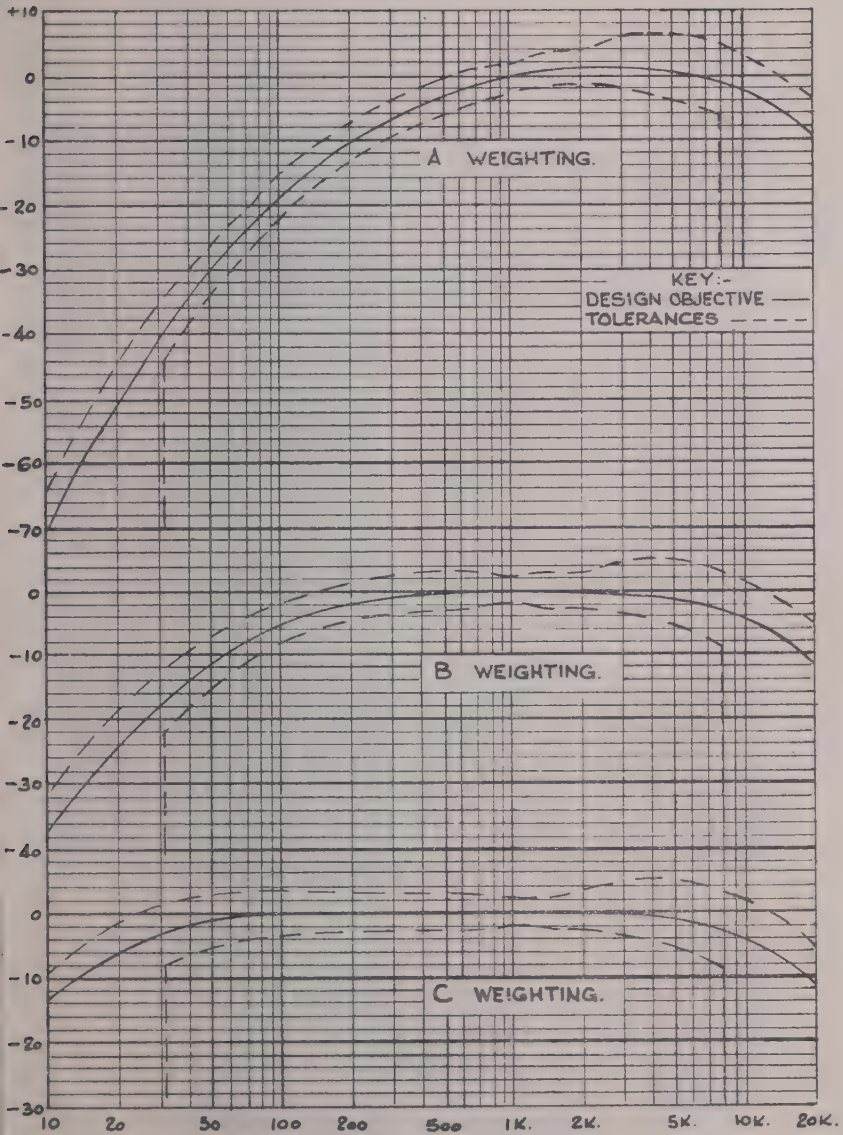


Fig. 3 RELATION BETWEEN LOUDNESS AND LOUDNESS LEVEL



C9518 (3)

Fig. 4 OVERALL FREQUENCY RESPONSE
I.E.C. Proposed Standard for Sound Level Meters

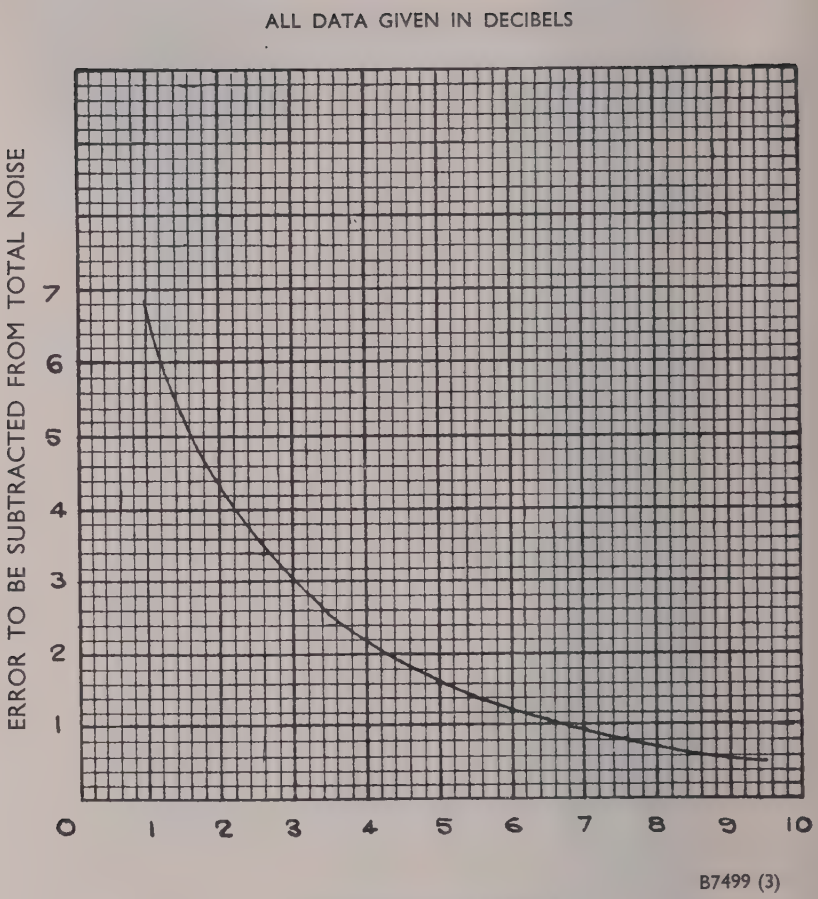


Fig. 5 CORRECTION FOR BACKGROUND NOISE

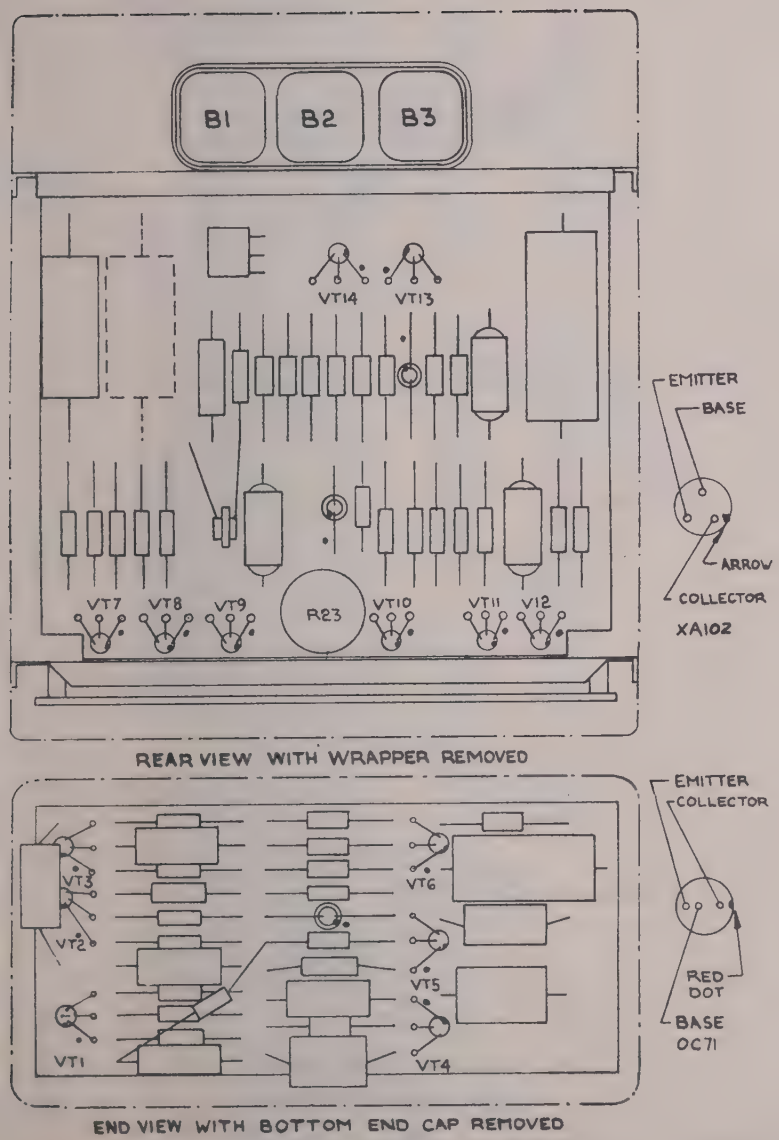
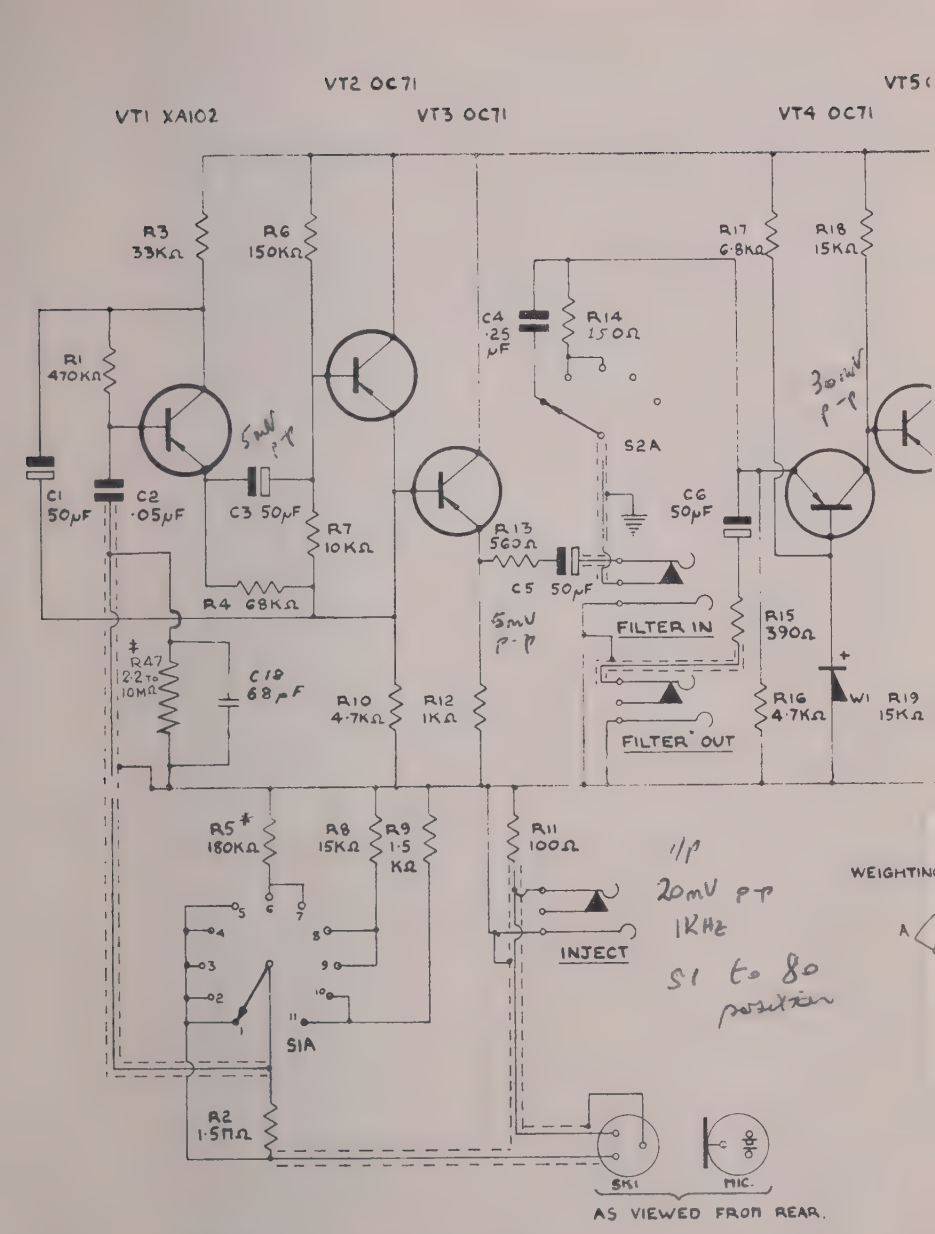


Fig. 6 LOCATION OF MAJOR COMPONENTS C10435 (1)

Fig. 7 CIRCUIT OF MAINS POWER UNIT

Type 1400E/PU C10463 (1)



NOTES

THE CASE OF C15 MUST BE EARTHED.

* R5 ADJUST ON TEST.

‡ R47 INSERTED ON TEST WHEN NECESSARY

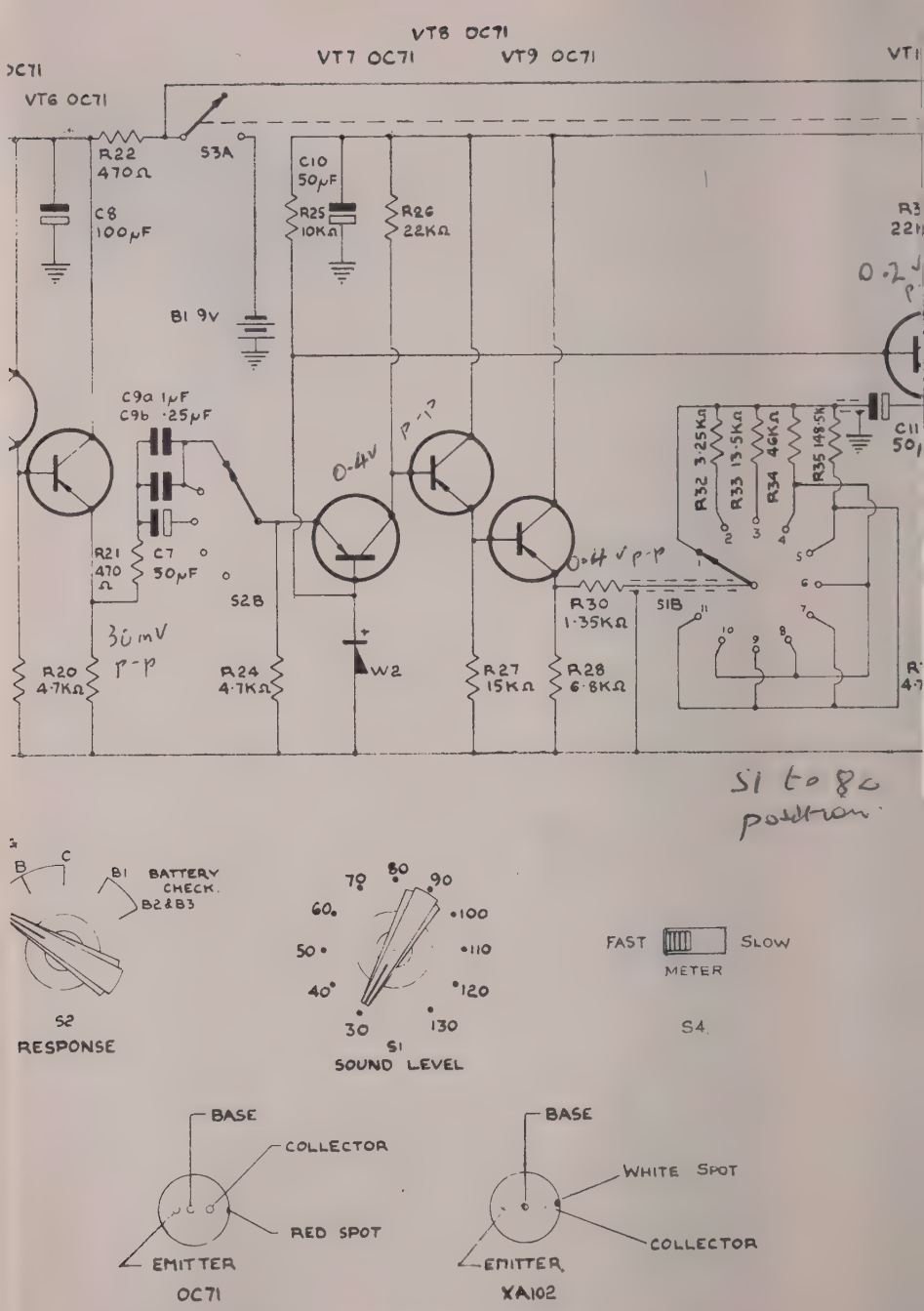
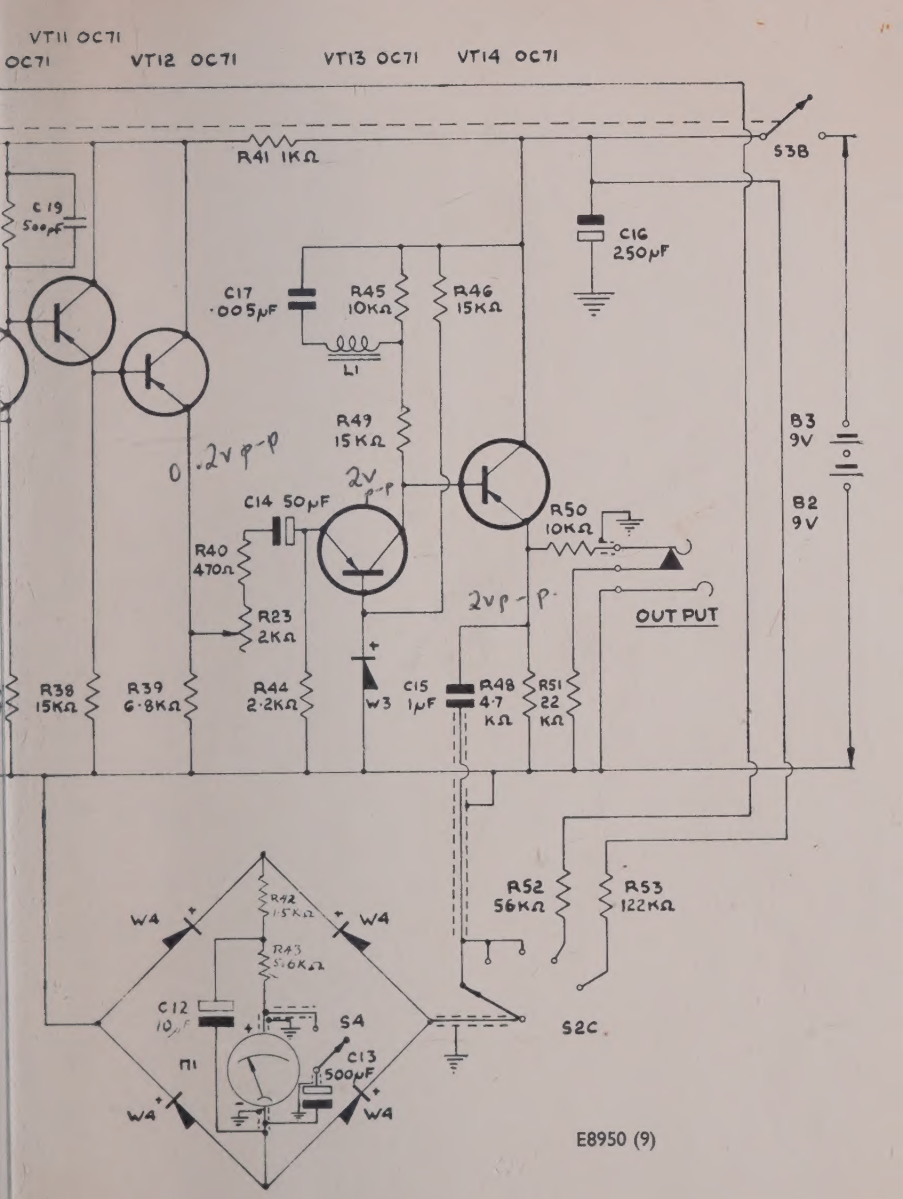


Fig. 8 CIRCUIT OF TRANSISTOR SOUND LEVEL METER TYPE 1400E


VT11 OC71
OC71
VT12 OC71
VT13 OC71
VT14 OC71
R41 1KΩ
S3B
C19 500pF
C16 250μF
C17 ·005μF
R45 10KΩ
R46 15KΩ
L1
R49 15KΩ
0 .2v p-p
2v p-p
B3 9V
B2 9V
C14 50μF
R50 10KΩ
R40 470Ω
R23 2KΩ
2v p-p
OUT PUT
R38 15KΩ
R39 6·8KΩ
R44 2·2KΩ
W3
C15 1μF
R48 4·7 KΩ
R51 22 KΩ
R52 56KΩ
R53 122KΩ
W4
R42 1·5KΩ
R43 5·6KΩ
C12 10μF
S4
S2C
M1
C13 500μF
E8950 (9)

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